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OPTIMIZATION

OF THE

FAUQUIER WATER TREATMENT PLANT

FOR

CONTROL OF TRIHALOMETHANES

SEPTEMBER 1997

Ontario

Ministry of
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Report prepared for:

Standards Development Branch
Ontario Ministry of Environment and Energy

EXECUTIVE SUMMARY

BACKGROUND

The two main objectives of the study are:

1. Improvement of the water treatment plant performance to meet the new Ontario Drinking Water Objectives (ODWO) THM guideline without compromising disinfection, to achieve a filter effluent turbidity of 0.1 NTU, and to meet the aluminum operational guideline of 100 µg/L.

2. Sustaining long term performance through skills transfer to plant operating staff and recommendations for plant upgrades where required.

The optimization study was funded by the Ontario Ministry of Environment and Energy (MOEE), and is a cooperative public/private project between the MOEE and RAL Engineering Ltd. By optimizing the performance of their existing facilities, municipalities should be capable of producing water that meets the new THM objective, and also be capable of improved particle removal and lower aluminum residuals, without requiring costly upgrades.

Trihalomethanes (THMs) are by-products created when the chlorine used in the disinfection process reacts with naturally occurring organics. Trihalomethanes are suspected of increasing the risk of cancer following long term exposure. The Ontario government has lowered the guideline from a maximum acceptable concentration of 350 µg/L, measured as a single occurrence, to an interim maximum acceptable concentration of 100 µg/L based on a running annual average of four quarterly samples.

The associated treatment parameters of turbidity and aluminum residual were also subject of the optimization effort. The ODWO for turbidity is 1 NTU, but current research now indicates that a filter effluent turbidity of 0.1 NTU is needed to provide protection from cryptosporidium. To reduce potential for disease outbreaks, this study will evaluate the feasibility to obtain a turbidity of 0.1 NTU in the filter effluent. The ODWO for aluminum in drinking water is 100 µg /L

The optimization of a water treatment plant consists of evaluating the existing treatment units, conducting laboratory testing to determine the best choice and dosage of the treatment chemicals and making changes to plant operation.

EXISTING CONDITIONS

The Fauquier Water Treatment Plant was built in 1971 and treats water from the Groundhog River. It is a conventional 'package plant' consisting of two Neptune Waterboy units containing a baffled mixing chamber, flocculation cell, clarifier with tube settlers, and dual media filter. The plant uses alum, polymer, soda ash and chlorine in the treatment process. The plant is owned and operated by the Township of Fauquier-Strickland. The plant is presently operated by one town staff person working 4 hours per day. The operator, Linda Beaudet, was very cooperative and showed a keen interest in achieving the best quality water possible.

A summary of historical data from June 1995 to May 1996 is presented as follow:

Parameters	***Units***	***Raw Water***	***Treated Water***
Turbidity	NTU	1.5 to 3.8	0.5 to 0.9
Colour	TCU	70 to 212	2 to 5
pH		6.7 to 7.6	6.9 to 7.4
Alkalinity	mg/L-$CaCO_3$	37 to 53	22 to 44
THM	µg/L		22 to 508

Plant flows are generally:	Average day	180 to 200 m^3/d
	Maximum daily flow	380 m^3/d.

PERFORMANCE ASSESSMENT

The river supply to the plant has high colour particularly in the spring runoff period. In general, the plant is well run with turbidity and colour being held within the MOEE guidelines. Variable quality of the treated water is observed and thus indicates more control over the treatment process is warranted.

Adjustments were made to the chlorination and soda ash application points, which have reduced the THM formation and improved disinfection. In addition, repairs were suggested and completed by the Township on the tube settlers.

Currently there are deficiencies in mixing, inadequate filter backwashing, and problems in the desludging of the clarifiers. Problems with low raw water pH and alkalinity causing an incomplete reaction with the alum was also reported early winter 1997.

A detailed assessment of the disinfection was made, after the in-plant adjustments, and there appear to be no problems for inactivation of giardia cysts as long as a minimum free chlorine residual of 0.5 mg/L is maintained at the plant and the minimum residual in the distribution system is maintained between 0.2 to 0.3 mg/L free chlorine residual.

The THM results obtained from on-site testing performed in September, 1996 at Fauquier Water Treatment Plant when testing a new coagulant aid, LT20, and after the relocation of the soda ash injection point to the high lift pump, show a level of THM in the treated water of 38 µg/L and 60 µg/L in the distribution system.

The turbidity of the treated water ranges from 0.4 to 0.9 NTU with an average of 0.7 NTU. While this is below the ODWO for turbidity of 1 NTU, it indicates less than optimum performance and the variabilty indicates a lack of control. This was felt to be a result of a lack of on-line monitoring instrumentation. In addition, aluminum residuals in the treated water have frequently exceeded the guideline of 100 µg/L.

OFF-SITE AND ON SITE TESTING

A preliminary screening study was performed on water collected at the plant and sent to the MOEE Water and Wastewater Optimization Section. This testing indicated both Alum and PACL performed well, however, the polymer LT 20 outperformed the polymer 8170 that was in use at the plant. Further on-site testing was conducted that confirmed these results. Relocation of the soda ash feed to the high lift pump suction area of the clearwell and revised desludging procedures were implemented at that time. In addition the plant operator was given some instruction on chemical dosing calculations and aluminum and free chlorine residual testing.

CONCLUSIONS

Modifications to the process during the optimization study appear to have reduced the THM formation to well below the new guideline. Further monitoring during the next summer will be carried out to confirm these results. It has been more difficult to achieve the goal of 0.1 NTU and the 100 μg/L maximum aluminum residual. This is likely caused by the deficiencies in mixing and flow control of the chemical feeds and the lack of in-line monitoring. To achieve the high levels of performance that provides the greatest protection against harmful organisms, it is necessary to have precise control over the addition of the treatment chemicals, have good dispersion of those chemicals and to have a continuous readout and record of the plant performance. This usually results in the added economic benefit of making the most effective use of these treatment chemicals.

RECOMMENDATIONS FOR PLANT SCALE MODIFICATIONS

The following is a summary of recommendations for plant and operational modifications required to ensure that Fauquier Water Treatment Plant will comply with the ODWO for THM and aluminum residual, will maintain adequate disinfection and will be more cabable of achieving a turbidity in the filter effluent of 0.1 NTU:

1. Shift alum addition to a common point downstream of new flow meter but before the split to Plant No 1 and No 2, install in-line static mixer immediately downstream from alum addition;
2. Install a mag. meter for raw water flow measurement;
3. Inspect filter underdrains in Plant No. 2 to determine the extent of the damage causing media to enter clearwell;
4. Provide continuous monitoring of settled water pH and alarm to alert operator of process upsets;
5. Sludge wasting is not adequate - increased operator attention of approximately 1 hour per day is needed. Automation of sludge removal may be consider as an option. Adequate draw down of the clarifier and sufficient flushing of the tubes is essential;
6. Install flow through turbidimeters and a recorder for Plants No 1 and 2 treated water;

7. Install a continuous soda ash feed to the raw water to offer the flexibility to do pH/alkalinity adjustment when needed;
8. Lower the chlorine dosage during the summer to a level ensuring that a minimum free chlorine residual between 0.2 to 0.3 mg/L can be maintained at the end of the distribution system. This will help to keep down THM levels;
9. Operate the plant to maintain a free chlorine residual of 0.5 mg/L in the winter;
10. Routine flushing of the watermains in the distribution sysytem to be able to apply and maintain a low chlorine dosage during the summer;
11. Install an improved backwash system for the filters by adding a manual air scour system;
12. Free AND total chlorine residual must be measured daily;
13. The operator should be given training needed to progress to the required level of certification.

COST ESTIMATE FOR IMPLEMENTATION

The following table is a summary of capital expenditure involved for the implementation of the recommended up-grades. The figures presented are preliminary estimates prepared to give an idea of the price range involved.

Capital Cost Estimates

PROPOSED MODIFICATIONS	COST ($)
Automation of sludge removal (Option)	$ 6,000
Mag. meter and chart recorder for raw water flow measurement	$ 8,000
Alum addition to a common point downstream of new flow meter but before the split to Plants Nos. 1 and 2 and install in-line mixer	$ 5,000
Manual air scour system for filters backwash	$ 20,000
Continuous monitoring of settled water pH	$ 7,000
Continuous monitoring of treated water turbidity	$ 9,000
Soda ash feed to the raw water	$ 5,000
TOTAL:	**$ 60,000**

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1.0 BACKGROUND

Trihalomethanes (THMs) are by-products created when the chlorine used in the disinfection process reacts with naturally occurring organics (eg. formed by decay of algae and vegetation) in raw water. Surface water containing high organics also often have high colour levels. The most common forms of trihalomethanes created are chloroform, bromodichloromethane, chlorodibromomethane and bromoform.

The formation of THMs is influenced by several factors:

• Free chlorine concentration	- higher Cl_2	= higher THM
• Organic content	- higher organic concentration	= higher THM
• pH	- higher pH	= higher THM
• Temperature	- higher temperature	= higher THM
• Time	- normally longer time	= higher THM

Since the formation of trihalomethanes is associated with the presence of organics in the water, small inland lakes and rivers, which may contain more organics than large clear bodies of water have a greater trihalomethane formation potential, especially during periods of high runoff.

The reason for adding chlorine to drinking water is to kill bacteria and other microorganisms that could cause numerous illnesses. However chlorine use leads to the presence of trihalomethanes and this is a cause for concern; studies have found an association between high levels of trihalomethanes in chlorinated drinking water, and slight increases in cancer following long term exposure of more than 35 years.

Chlorine has an advantage over other disinfectants in that it persists many hours or for days and provides protection for the entire water distribution system. The benefit to public health of using chlorine as a disinfectant in drinking water far out-weighs the risk to health associated with the low levels of trihalomethanes created as by-products of chlorination.

In order to decrease the health risk from trihalomethanes, the Canadian and Ontario governments have lowered their respective guideline limits from an "anytime" maximum acceptable concentration of 350 μg/L, measured as a single occurrence, to an interim maximum acceptable concentration of 100 μg/L based on a running annual average of four quarterly samples.

Disease outbreaks caused by giardia and cryptosporidium have been reported with increased frequency over the last decade in Canada and the US. These protozoan parasites (especially cryptosporidium) are more difficult to kill than bacteria with disinfectants, and therefore their removal by physical processes is vital. As a result, Health Canada is now examining the need for stricter standards for particle removal in water plants. The current Ontario Drinking Water Objective (ODWO) for turbidity that applies at the water treatment plant is 1 NTU, but current US research and experience now indicates that a filter effluent turbidity of 0.1 NTU is needed to provide protection from cryptosporidium. In the attempt to reduce potential for disease outbreaks, this study attempted to evaluate the feasibility to obtain a turbidity of 0.1 NTU in filter effluent.

Alum (aluminum sulphate) is the most widely used coagulant because it is effective, readily available, and relatively inexpensive. However, under some circumstances, or if not used properly, its use can result in elevated levels of residual aluminum in finished drinking water. An article was recently published on facts about human health and aluminum in drinking water (Environmental Science and Engineering Magazine, January 1997). The following is a summary of the major facts presented in the article.

In recent years, increased attention has been focused on possible adverse effects of aluminum in drinking water on human health. Several epidemiological studies have reported a slightly increased incidence of dementia in communities where drinking water is high in aluminum and these studies have raised concerns among the media and public. A number of theories on the causes of Alzheimer's disease have been proposed and are currently under investigation. From what we know at this time, the evidence linking aluminum and Alzheimer's disease is far from conclusive, but we also cannot be sure that there is no relationship. Humans are constantly being exposed to aluminum via food, air, and water. Ninety percent (90%) of aluminum intake is from food. In general, exposure to aluminum from drinking water is very low (below 3%) compared with that from food and drugs. At the present time the ODWO for aluminum in drinking water is 100 ug/L, which is an operational not health related guideline.

Owners of water treatment plants and water distribution systems who provide water for consumption have legal responsibilities which are shared by all suppliers of food or drink. Owners and suppliers must take reasonable measures to ensure the water is fit for safe consumption.

This optimization study is funded by the Ontario Ministry of Environment and Energy (MOEE), and is a cooperative public/private project between the MOEE and RAL Engineering Ltd. By optimizing the performance of their existing facilities, municipalities with a conventional water treatment plant (i.e. coagulation, flocculation, settling, filtration and disinfection) in many cases should be capable of producing water that meets the new THM objective, and also be capable of improved particle removal, without resorting to costly upgrades. The optimization of a water treatment plant consists of:

- Documentation of existing facility.
- Assessment of the performance of each process unit.
- Verification of the hydraulic loading on each process.
- Laboratory jar testing to determine the best combination of treatment chemicals and the optimum dosages to achieve maximum removal of particulates and dissolved organic material, as well as a minimum level of aluminum residual in the treated water.
- Make required changes to plant operation at full-scale to ensure that changes will minimize the formation of THM, but will not compromise the disinfection requirement.

2.0 OBJECTIVES

The two main objectives of the study are:

1. IMPROVEMENT OF FAUQUIER WATER TREATMENT PLANT PERFORMANCE

- Improve plant performance without major capital/equipment expenditures. Specific water quality objectives are listed below in decreasing order of priority:

    i To comply with the 100 µg/L ODWO for THMs in treated water as a running annual average of 4 quarterly samples. This objective shall be met while ensuring proper removal and/or inactivation of disease-causing microorganisms such as bacteria and viruses, since this remains the most critical aspect of drinking water treatment.

    ii To improve particulate removal to reduce or eliminate disease risk from giardia and cryptosporidium. While the ODWO for turbidity is 1.0 NTU, the goal is to achieve 0.1 NTU in the filter effluent.

    iii To keep aluminum residual at or below 100 µg/L to meet the ODWO.

2. SUSTAINING LONG-TERM PERFORMANCE

- Skills transfer to plant operating staff to enable them to effectively control and adjust processes over the long term in response to raw water quality variations.
- Documentation of plant conditions with recommendations for up-grades and operational modifications.

3.0 DOCUMENTATION OF EXISTING CONDITIONS

The water treatment plant was built in 1971. The plant is owned and presently operated by the Township of Fauquier-Strickland. There is one operator on staff working 4 hours per day. A plant survey was performed during a site visit on June 17, 1996 to prepare a detailed description of the existing equipment and the condition of operation. The survey is documented in Appendix A. A plant schematic is presented in Figure 3.1.

The raw water characteristics are:

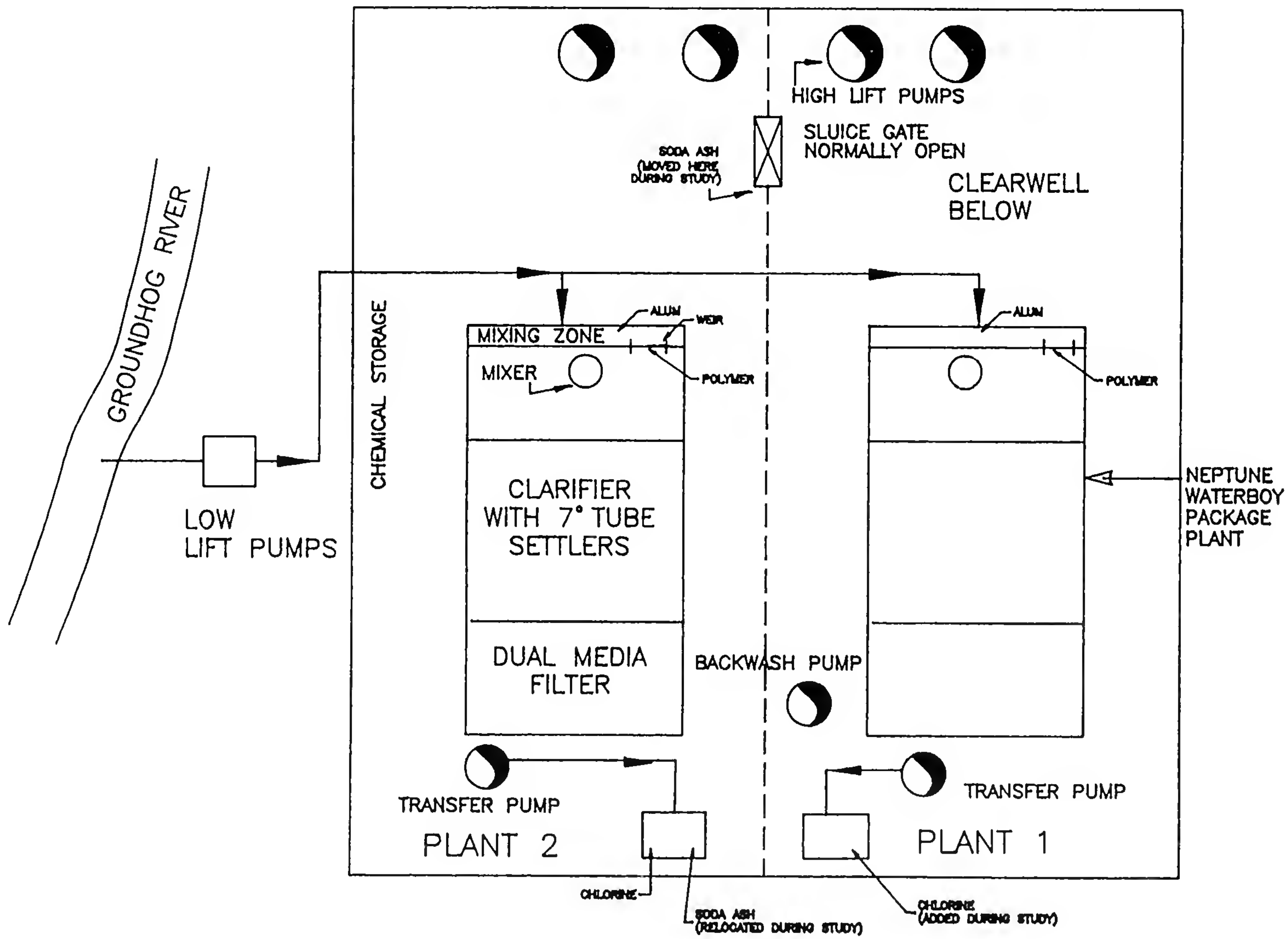
Colour:	30 to 80 TCU (July -Sept 96)
Turbidity:	2 to 6.7 NTU
pH:	7.8 to 8.1
Alkalinity:	47 to 77 mg/L

Plant flows are generally:	Average day	180 to 200 m^3/d
	Maximum daily flow	380 m^3/d.

The water treatment plant consists of:

- ⇒ Low lift pumping station drawing raw water from the Groundhog River.
- ⇒ Raw water supply main to the adjacent treatment plant.
- ⇒ Coagulant feed systems for alum and polymer
- ⇒ Two Neptune Waterboy package water treatment plants
- ⇒ Two cell clearwell storage under the plant
- ⇒ Chlorine and soda ash injection into the clearwell
- ⇒ Vertical turbine high lift pumps

At the start of the optimization project, one of the Waterboy plants was operating automatically and one operated manually. The manually operated plant ran 24 hours per day resulting in frequent overflows from the clearwell.



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FAUQUIER WATER
TREATMENT PLANT
SCHEMATIC

SCALE	FIGURE
NTS	3.1

3.1 THE PACKAGE PLANT

Two Neptune Waterboy units operate in parallel and discharge to a two-celled clearwell that is interconnected in the vicinity of the high lift pumps. Each treatment unit contains a baffled mixing section weir, mechanical flocculation, sedimentation using tube settlers angled at 7 degrees to horizontal, and a dual-media filter. Effluent from the filter is pumped to the clearwell with a transfer pump. The clearwell is located below the treatment units. The filters are backwashed with a separate pump. There is no surface wash or air scour provided with the package plant. The filter media is washed with caustic soda every three months to control mud ball and slime formation. On each backwash cycle the clarifier drains to flush out the shallow angled tubes and the operator rinses the tubes with high pressure water spray to remove sludge (floc) accumulations.

A process unit model is as follows:

MIXING	FLOCCULATOR	CLARIFIER WITH TUBE SETTLERS	FILTER
	L 1.85 m	L 1.85 m	L 1.85 m
	W 1.22 m	W 1.02 m	W 0.97 m
	D 1.52 m	D 1.80 m	D 1.80 m
NONE	VOL 3.4 m3	AREA 1.88 m2	AREA 1.8 m2
		VOL 3.4 m3	VOL 3.2 m3
	MIXER 0.19 kW	RATE 4.20 m/h	RATE 4.42 m/h
	G 142 s-1	TIME 26 min	
	Gt 221,971		
	TIME 26 min		

MOEE GUIDELINE

1000 s-1	Gt 50,000	Min. 3.8 m/h	Recom. 9 m/h
	to 125,000	to 5.8 m/h	Max. 12 m/h

A description of the process unit operations associated with the plant are:

3.1.1 Rapid Mixing

There is essentially no rapid mixing in the plant. Alum is added to the first compartment of the plant and relies on hydraulic turbulence which is not strong in this area. Mixing energy is well below the MOEE guideline values. Polymer is added at the rectangular weir and relies on the turbulence of the falling water. The MOEE guideline for rapid mix is for an energy gradient of 1000 s^{-1}.

Adequate mixing energy is required for rapid dispersion of the coagulant. Coagulants react (hydrolyze) in water very quickly. In order to be effective the chemical must be mixed rapidly and thoroughly to come in contact with all of the raw water during this critical stage.

3.1.2 Flocculation

The flocculation tank is equipped with a fixed speed mechanical flocculator. The existing input energy is higher than recommended. The range of acceptable flocculation input energy is wide however (50,000 to 125,000), and there does not appear to be shearing of floc as a result of the higher energy input.

3.1.3 Sedimentation

The sedimentation tank is equipped with tube settlers angled at 7 degrees. This provides a relatively high effective settling area however, the shallow angle makes sludge removal difficult and requires that the water level be dropped below the tubes each time the clarifier is de-sludged to flush the tubes clean. The filters then are backwashed into the clarifier and back through the tubes to further flush out the sludge.

The older plant (Plant No.1) operates in full automatic backwash control but it is reported by the operator that the clarifier does fully drain prior to the start of the filter backwash and that there is insufficient time to flush the tubes completely. This unit has had a tube module crushed due to accumulated sludge. Plant No. 2 is backwashed manually allowing the operator to fully drain the clarifier and flush the tubes. This unit is reported to perform better than the older Plant No. 1.

The rise rate of 4.2 m/h at existing maximum day flows is within the MOEE guideline of 3.8 to 5.8 m/h however, the efficiency of the tubes depends on the effective cleaning, and build-up of sludge reduces the open area and increases the effective velocity causing floc carry through.

The end plate in Plant No. 1 was separating from the tubes at the time of the initial site visit which was allowing substantial by-pass of floc to the filters. This was corrected during the course of the optimization project.

3.1.4 Filtration

The existing dual media filters are operating at a very low filtration rate of 4.4 m/h at existing maximum day flows. This compares to the MOEE recommended rate of 9 m/h for a plant of this size and type. There is one backwash pump pumping the water from the clearwell during filter backwash. The filters are prone to plugging however and require frequent cleaning with caustic soda. This is most likely caused by inadequate backwashing. There is no surface wash or air scour provided with the package plant and experience has proven that additional agitation of the media, from that provided by the backwash alone, is required.

Effluent from the filters is transferred by pump to the clearwell even though the clearwell is below the filter floor. This seems to be a carry over from an 'off the shelf'

package that would allow the effluent to be pumped to a tank at the same level as the filters. It would be possible to re-pipe the effluent line and remove the pump without any detrimental effect on the plant operation.

3.1.5 Clearwell

The clearwell useful volume is 682 m^3 (150,000 IG). It is made of two cells with no baffles. The overall dimensions of the clearwell are 11.6 m X 16.8 m X 4.45 m deep. There is no other storage tank in the community.

3.1.6 High Lift Pump

There are three vertical turbine pumps available at the plant. Two pumps have a power of 5.6 kW (7.5 HP), and the third pump, 22.4 kW (30 HP). There were no issues related to high lift pumping.

3.1.7 Wastewater Disposal

The wastewaters generated from the clarifier blowdown and the filter backwash are discharged to the sewer for treatment in the municipal lagoon.

3.2 CHEMICAL FEED SYSTEMS

The chemical feed systems at beginning of the optimization were:

Process Function	*Chemical*	*Locations Added*
Primary coagulant	Liquid alum	Inlet to each package plant
Coagulant aid	8170 polymer	Weir between mixing zone and flocculation tank
Disinfection	Sodium Hypochlorite	Clearwell Inlet - Plant No. 2
pH Adjustment	Soda ash.	Clearwell Inlet - Plant No. 2

The water treatment plant has not been pre-chlorinating for two years.

3.2.1 Alum

The operator bases the alum dose on treated water colour and filter influent pH. Alum feed tank volume is 668 L. The operator dilutes 48.5% liquid alum (General Chemical) by 50%. This solution is drip-fed into the mixing zone portion in each of the plants.

3.2.2 Polymer Feed

The polymer feed tank volume is 1044 L. The polymer solution (8170) was mixed in the tank and fed directly without further dilution to each of the plants - the polymer is drip-fed into the water overflowing the weir into the flocculation chamber. The operator adds 0.45 kg (1 pound) of dry polymer to the tank in warm months and 0.9 kg (2 pounds) in winter.

3.2.3 Chlorine

Twelve percent (12 %) nominal strength sodium hypochlorite was fed into one cell of the clearwell adjacent to the clearwell inlet and then, blended with the flow from the other cell at the high lift pumps. The applied dosage has ranged from 2.4 to 6.4 mg/L. The application point was changed during the course of the study such that each plant controlled a dedicated hypochlorite pump and the chlorine was fed into the respective side of the clearwell.

3.2.4 Soda ash

Soda ash was made up in a solution tank and fed into the same clearwell cell as the chlorine, adjacent to the clearwell inlet. Soda ash was added to the clearwell to raise the pH of the filter effluent from pH 5.9 to pH 7.5, to provide protection against corrosion in the distribution system.

3.3 FLOW MEASUREMENT

For Plant No. 1 operating in automatic mode, the operating time is recorded. The head end of the plant is equipped with a rectangular weir and head measurement indicator for measuring flow rate. With this information a daily volume of raw water passing through Plant No.1 can be calculated. The operator uses a chart prepared by Ontario Clean water Agency (OCWA) that converts the weir head to a flow rate in m^3/h. Plant No.2 is equipped with a similar weir, but the time of operation is estimated by the operator. Treated water flow is measured by a turbine flow meter with totalizer.

3.4 HISTORICAL DATA

A summary of historical data from June 1995 to May 1996 is presented in Table 3.1, which summarized monthly average values for turbidity, colour, pH and alkalinity found in the raw water and the treated water. The water samples were analyzed by the plant operator. The range and annual average from the data in Table 3.1 are summarized below:

Parameters	*Units*	*Range*	*Average*
Turbidity - Raw Water:	NTU	1.5 to 3.8	2.3
Turbidity - Treated Water:	NTU	0.5 to 0.9	0.6
Colour - Raw Water:	TCU	70 to 212	115
Colour - Treated Water:	TCU	2 to 5	3
pH - Raw Water:		6.7 to 7.6	7.4
pH - Treated Water:		6.9 to 7.4	7.1
Alkalinity - Raw Water:	mg/L-$CaCO_3$	37 to 53	43
Alkalinity - Treated Water:	mg/L-$CaCO_3$	21 to 44	33
THM - Treated Water:	µg/L	22 to 508	170
THM - Distribution System:	µg/L	23.5 to 269	104

The variation of turbidity in the raw and the treated water from January to December is presented in Figure 3.2. The turbidity reaches a peak in May and October. The variation of colour in the raw and the treated water for Fauquier WTP is presented in Figure 3.3. The raw water colour reaches its maximum value in May and October. High levels of THM were observed in August 1995 with 508 µg/L for the treated water at the water treatment plant, and 269 µg/L in the distribution system.

TABLE 3.1 FAUQUIER WATER TREATMENT PLANT

MONTHLY AVERAGE WATER QUALITY RESULTS - 1995 AND 1996

WATER SAMPLES ANALYZED BY THE WTP STAFF (EXCEPT FOR THM)

	Jun-95	Jul-95	Aug-95	Sep-95	Oct-95	Nov-95	Dec-95	Jan-96	Feb-96	Mar-96	Apr-96	May-96	AVERAGE
TURBIDITY - RAW WATER (NTU)	3.0	2.8	2.4	1.9	2.9	2.6	1.8	1.5	1.5	1.5	1.9	3.8	2.3
TURBIDITY - TREATED WATER (NTU)	0.7	0.6	0.5	0.6	0.8	0.5	0.5	0.6	0.5	0.7	0.8	0.9	0.6
COLOUR - RAW WATER (TCU)	148	142	116	88	149	122	82	76	70	80	100	212	115
COLOUR - TREATED WATER (TCU)	4	4	3	2	5	3	2	2	2	3	2	4	3
pH - RAW WATER	7.5	7.4	7.4	7.6	7.4	7.4	7.4	7.6	6.7	7.2	7.3	7.4	7.4
pH - TREATED WATER	7	7	7	7	7	7	6.9	7	7	7.2	7.4	7.4	7.1
ALKALINITY - RAW WATER (mg/L-CaCO3)	42	37	35	50	53	41	41	39	39	37	50	52	43
ALKALINITY - TREA. WATER (mg/L-CaCO3)	33	30	30	38	44	30	29	29	21	30	41	40	33
THM - TREATED WATER (ug/L)	—	—	508	—	—	—	—	22	—	—	—	—	265
THM - DISTRIBUTION SYSTEM (ug/L)	—	—	269	—	—	—	—	23.5	—	—	—	—	146

NOTES:

THM RESULTS FOR TREATED WATER AND DISTRIBUTION SYSTEM IN JUNE 1996 WERE 95 AND 67 ug/L.

THM RESULTS FOR TREATED WATER AND DISTRIBUTION SYSTEM IN JULY 1996 WERE 55 AND 58 ug/L

FIGURE 3.2 TURBIDITY FOR FAUQUIER WTP

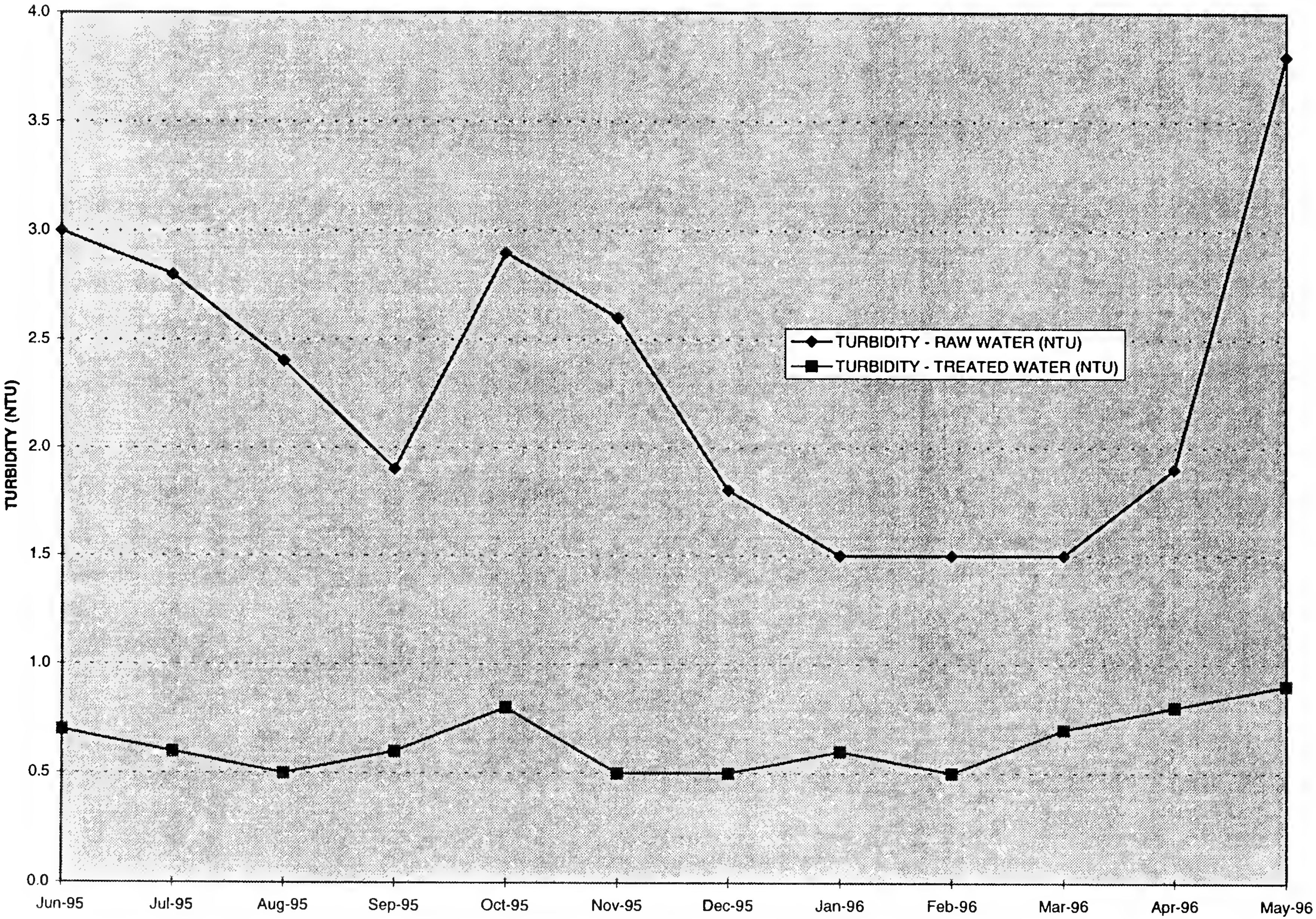
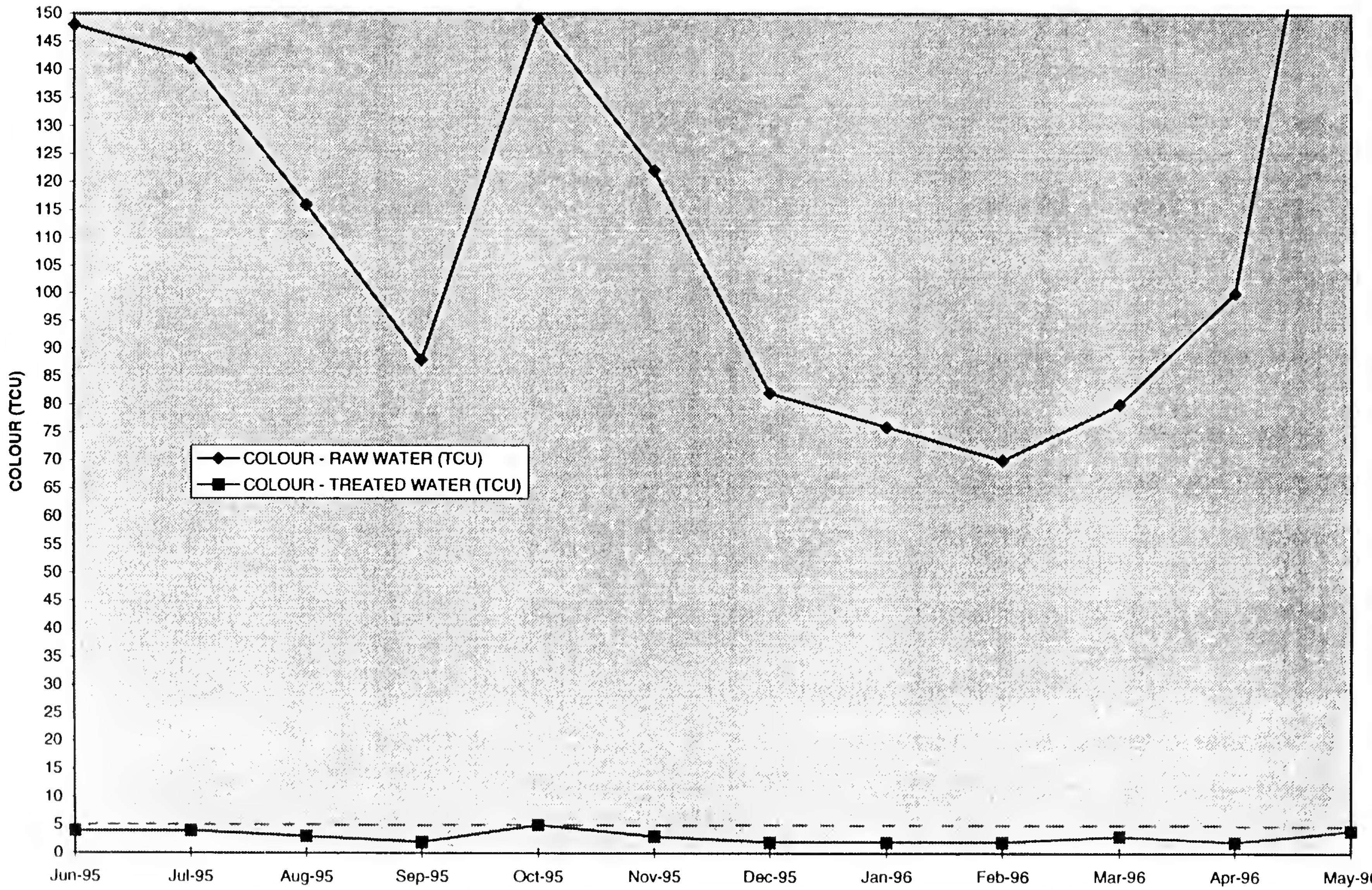


FIGURE 3.3 COLOUR FOR FAUQUIER WTP



4.0 PERFORMANCE ASSESSMENT

4.1 JULY, AUGUST AND SEPTEMBER SAMPLING

The river supply to the plant is high in colour and variable in quality particularly in the spring runoff period. In general the plant is well run with turbidity and colour within the MOEE guidelines however, the variable range in quality for the treated water (turbidity ranging from 0.4 to 1.6 NTU, and colour from <1 to 13.5 TCU), indicates more control over the treatment process is warranted. In general, variable treated water quality would indicate a higher risk of a breakthrough of turbidity and possibly harmful organisms such as giardia and cryptosporidium that may not be caught in the regular daily monitoring. A good consistent effluent indicates good control of the process and gives confidence in day to day performance.

Additional water samples were collected at the treatment plant in July, August and September 1996 to establish a baseline for THMs versus the level of colour and Total Organic Carbon (TOC). The samples were analyzed by Novamann. The results obtained from 8 weeks of sampling are summarized in Table 4.1. The operation data collected at the water treatment plant for the days of sampling including average daily flow, turbidity, raw water temperature and chemical dosages are presented in Table 4.2.

THMs were in excess of the MOEE guideline for the water samples taken during the first, the third and the fourth week of July with levels ranging from 120 to 140 μg/L in the distribution system. It is noted from Table 4.1 that a low free chlorine residual was measured at the plant for the second week of July (15/07/96), possibly lower than the total chlorine residual of 0.49 mg/L presented in Table 4.2. This explains the low THM measured at the plant (49 μg/L) and in the distribution system (55μg/L) for that week.

Due to a miscommunication, the chlorine injection point was moved to the end of the clearwell next to the high lift pumps. This resulted in much lower THM formation for the first and the second week of August, but did not provide adequate chlorine contact time. The operator was asked to move the chlorine back to the head of the clearwell.

TABLE 4.1 JULY, AUGUST AND SEPTEMBER 1996 SAMPLING FOR FAUQUIER WATER TREATMENT PLANT WATER SAMPLES ANALYZED BY NOVAMANN

PARAMETERS	WEEK 1 (09/07/96)	WEEK 2* (15/07/96)	WEEK 3 (23/07/96)	WEEK 4 (29/07/96)	WEEK 5** (06/08/96)	WEEK 6** (13/08/96)	WEEK 7 (28/08/96)	WEEK 8 (04/09/96)	MINIMUM	MAXIMUM	AVERAGE
Turbidity - Raw Water (NTU)	5.8	5.5	4.4	6.2	6.7	4.5	3.9	5.0	3.9	6.7	5.3
Turbidity - Treated Water (NTU)	0.5	0.4	0.5	0.8	1.6	0.8	1	0.9	0.4	1.6	0.8
Colour - Raw Water (TCU)	41.6	81.4	62	61.1	83	29.6	47.1	46.3	29.6	83	56.5
Colour - Treated Water (TCU)	3	7	3	13.5	12	2	3	1	1	13.5	5.6
Colour - Distribution System (TCU)	4	7	4	11.5	8.7	2	2	1	1	11.5	5.0
pH - Raw Water	8.09	8.01	8.01	7.94	8.1	8	7.85	8.1	7.85	8.1	8.0
pH - Treated Water	8.51	8.27	8.67	7.63	7.7	6.93	7.89	7.82	6.93	8.67	7.9
Alkalinity - Raw Water (mg/L - $CaCO_3$)	47	52	52	50	57	77	62	54	47	77	56
Alkalinity - Treated Water (mg/L - $CaCO_3$)	82	82	97	54	30	54	64	82	30	97	68
TOC - Raw Water (mg/L)	13.5	13	6.6	8.2	11	21.1	8.8	8.8	6.6	21.1	11.4
TOC - Treated Water (mg/L)	3.6	3.9	2.6	4	4.4	2.4	1.9	2.6	1.9	4.4	3.2
TOC - Distribution System (mg/L)	3.9	3.7	2.4	3.5	3.7	2.4	2.4	2.5	2.4	3.9	3.1
TTHM - Unquenched Treated Water (ug/L)	100	49	190	160	48	23	98	51	23	190	90
TTHM - Quenched Distribution System (ug/L)	140	55	130	120	58	26	97	50	26	140	85

Note: * : Low free chlorine residual was found at the plant during the week 2.
** : Chlorine injection was accidentally moved to the high lift pumps, which explains low THM values observed for week 5 and week 6.

TABLE 4.2 JULY, AUGUST AND SEPTEMBER 1996 SAMPLING FOR FAUQUIER WATER TREATMENT PLANT OPERATION DATA COLLECTED AT THE WTP

PARAMETERS	WEEK 1 (09/07/96)	WEEK 2 (15/07/96)	WEEK 3 (23/07/96)	WEEK 4 (29/07/96)	WEEK 5 (06/08/96)	WEEK6 (13/08/96)	WEEK7 (28/09/96)	WEEK8 (04/09/96)	MINIMUM	MAXIMUM	AVERAGE
Average Daily Flow (m3/d)	186	161	161	152	225	N/A	156	222	152	225	180
Turbidity - Raw Water (NTU)	2.9	3.1	3	2.6	2.4	N/A	2.4	2.8	2.4	3.1	2.7
Turbidity - Treated Water (NTU)	0.7	0.9	0.6	0.9	0.4	N/A	0.7	0.5	0.4	0.9	0.7
Temperature - Raw Water (Degree Celsius)	16	17	18	18	19	N/A	15	16	15	19	17
Free Chlorine Residual (mg/L)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Total Chlorine Residual (mg/L)	0.51	0.49	0.54	0.5	0.5	N/A	0.6	0.5	0.49	0.6	0.52
Alum Dosage (mg/L)	40.9	94.3	42.5	43	50.3	N/A	97.1	79.8	40.9	97.1	64.0
Coagulant Aid Dosage - 8170 (mg/L)	0.14	0.16	0.15	0.19	0.15	N/A	0.21	0.29	0.14	0.29	0.18
Soda Ash Dosage (mg/L)	25.2	36.2	28	22.1	17.3	N/A	53.3	43.8	17.3	53.3	32.3
Chlorine Dosage (mg/L)	5.4	2.4	5.7	5.1	6.4	N/A	10.8	7.6	2.4	10.8	6.2

N/A: Not Available

The soda ash injection was moved to the end of the clearwell in September 1996, to improve disinfection and potentially reduce THM formation, since THM production increases in proportion to increases in the pH. Changing the soda ash injection point to the high lift end of the clearwell seems to have lowered THMs.

THM levels in the distribution system before the soda ash feed was moved were 140, 130, 120 and 97 μg/L (July 1996), not including samples taken on days with very low free residuals or when the chlorine feed was incorrectly moved to the high lift. Temperature ranged from 15 to 19°C. Following the move, THM in the distribution system were 50 μg/L (September 4) and 62, 66, 64 and 56 μg/L (September 23 to 26) (see Table 6.2). The temperature of these samples was 16°C in early September and 13°C in late September.

The average colour measured during the summer sampling was 56.6 TCU for the raw water and 5.6 TCU for the treated water. Based on THM, colour and TOC analysis performed for Fauquier Water Treatment Plant, there is no evidence of a direct relation between the level of colour or TOC in the water and the level of THM formed. The lack of THM-colour correlation is somewhat unexpected since in general the higher the colour, the higher the organic content, therefore producing higher THMs. In addition to the limited number of samples collected, other factors which may have contributed to the lack of correlation include the narrow range of colour value observed, and the analytical variability for THM analysis. The detection limit of the analytical procedures and the method reference used by Novamann is summarized in Appendix E.

The water samples taken in the distribution system for THM analysis were quenched with sodium thiosulfate to remove any chlorine residual to stop any further reaction between free chlorine and organics. Quenched water samples will maintain the same level of THM as existed at the time of sampling representing the quality experienced by the consumer. The water samples taken at the water treatment plant for THM analysis were not quenched, the reason being to simulate the effect of additional contact time in the distribution system versus the development of THM.

4.2 PROCESS UNIT ASSESSMENT

During the site visit in June a number of suggestions were made to improve process performance. Those items that were readily implemented by the Township were changed during the course of the optimization project. These were:

4.2.1 Completed Modifications

√ All of the chlorine being dosed was being added to the effluent from one package plant unit (Plant No. 2) in one cell of the clearwell while the discharge from the other unit and the other cell was not chlorinated. The waters would then blend near the high lift pump to provide the final residual. This practice would have two undesirable effects. The high residual in the chlorinated cell would drive the THM formation faster and the unchlorinated cell would not have adequate disinfection. It was recommended to install a second chlorine feed pump and to add chlorine to each filter plant discharge. This was completed by the Township staff in October 1996. There was no discernible change in THM formation however, there was a significant improvement in disinfection.

√ The soda ash addition was located at the discharge of the treatment units. This was relocated to the opposite end of the clearwell in September 1996 to delay the increase in pH. The effect of this was to significantly reduce THM formation and further improve disinfection.

√ The newest package plant was being operated in manual mode 24 hours a day. This resulted in periods of overflow from the clearwell. This plant was converted to automatic start/stop operation in the early summer 1996 and this saved up to 20% of the treated water production by elimination of the overflow condition.

4.2.2 Outstanding Unit Process Deficiencies

There are deficiencies with the plant process configuration when compared to MOEE guidelines and generally accepted treatment practice as noted in Chapter 3.1. These are:

Flow Measurement

It is suspected that the rectangular weir and head measurement used to evaluate flow rates in m^3/h does not provide accurate measurement since the head is only approximately 4 cm. The ISCO Inc. open channel manual states that the weir should have a head of at least 6 cm. Raw water flow is one of the main parameters used when calculating chemical dosages. It is critical therefore, to have accurate flow measurement. The raw water line should be fitted with a flow meter, preferable a magnetic type, with flow and totalized readouts and a chart recorder.

Mixing

There is inadequate mixing of treatment chemicals. The front end of the Waterboy plant has a small contact chamber for chemical injection but relies totally on hydraulic turbulence for mixing. More effective use of the chemicals and more consistent performance could be achieved with the addition of an in-line blender in the raw water line for alum injection and by moving the polymer addition to the existing mixing zone.

Flocculation

The input energy is higher than required and there is no allowance for varying flocculator speed to adjust for conditions such as temperature and flow. The flocculation process is relatively insensitive to mixing energy input within a broad range, the upper limit being the point where floc shearing is occurring. What is critical is having adequate time for the particles to agglomerate especially in cold water conditions. The Fauquier plant has adequate residence time in the flocculator. There may be some benefits in converting the mechanical flocculator to variable speed however, the effect would be small and is not recommended at this time.

Clarification

The tubes in clarifier No. 1 are not getting adequately cleaned due to the sequence of the automatic operation. The clarifier timed sequence should allow the unit to be drained completely after the filter backwash and give the operator time to hose out the tubes prior to restarting the inflow. The efficiency of the shallow inclined tubes is dependent on their effective cleaning on each backwash cycle.

Filtration

The filtration rate of these filters is very conservative and should be capable of very efficient turbidity removal. There is however inadequate filter washing due to a lack of surface wash or air scour system. This causes the media to plug up and significantly reduces the filtration efficiency.

Disinfection

Disinfection of drinking water is the most important aspect of the treatment process. Harmful organisms in water such as bacteria, viruses or cysts can cause illness ranging from minor intestinal disorders to potentially fatal infections. Maintaining an effective disinfection system must be the overriding priority of the plant operations. For surface waters, chlorination with a 'free' residual is the most common and most practical method of disinfection. To be effective, the treated water must be very low in turbidity as suspended particles can shield bacteria and virus from the effect of chlorine. Turbidity levels greater than 0.1 NTU indicate an increased probablity of chlorine resistant cysts being present.

To achieve a safe level of disinfection, it is necessary to dose the treated water with a sufficient amount of chlorine to produce a 'free' residual, and to give the chlorine sufficient time to inactivate the potentially harmful organisms. This is called the concentration-time factor or CT, also referred to as the primary disinfection stage. Sufficient CT must be achieved at the

treatment plant before the first service connection. Current MOEE guidelines call for a minimum residual of 0.5 mg/L for a minimum contact time of 30 minutes after filtration. This disinfection guideline for water treatment plants in Ontario is under review, and the new guideline may be similar to the Surface Water Treatment Rule (SWTR) promulgated by U.S. Environmental Protection Agency (U.S. EPA). The SWTR established CT values for chlorine, chlorine dioxide, ozone and chloramines required to achieve adequate inactivation of giardia cysts and viruses. For the purpose of calculating CT value, T is the time (in minutes) it takes the water, during peak plant flows, to move between the point of disinfectant application and a point where, C, residual disinfectant (in mg/L) concentration is measured just prior to the first customer. The calculation must take into account the degree of short circuiting in the storage tank.

For free residual chlorination, the CT required is based on the inactivation of giardia cysts in cold water. Giardia cysts are harder to inactivate by free chlorine than viruses, therefore, it is implied that proper inactivation of giardia cysts will ensure inactivation of viruses. Disinfection is not effective for the inactivation of cryptosporidium therefore, it is necessary to perform adequate filtration at the water treatment plant for any municipality at risk of cryptosporidium outbreaks.

Secondary disinfection refers to the maintenance of a residual in the distribution system to protect against bacterial re-growth or minor cross connection contamination. This maintenance residual is commonly achieved with 'free' chlorine, but alternatively can be converted to chloramine or 'combined' residual with the addition of ammonia. Chloramines have the advantage of being more stable and lasting much longer in the system. They also do not react with organics to form THMs. They are however much less effective as a disinfectant and are very weak in inactivating viruses and cysts. Use of chloramine as a primary disinfectant is therefore not recommended.

The MOEE guidelines recommend a minimum free chlorine residual of 0.2 mg/L at the end of the distribution system. The AWWA recommends a residual of 1.0 mg/L of chloramine be maintained to prevent re-growth (AWWA, 1993). These chlorine residuals do not take into consideration water characteristics such as temperature and pH that affect disinfection efficiency.

According to the SWTR, all community and noncommunity public water systems which use a surface water source or a ground water under the direct influence of a surface water must achieve a minimum of 99.9 percent (3-log) removal and/or inactivation of giardia cysts. According to these guidelines, systems with sewage and agricultural discharges to the source water should provide treatment to achieve an overall 99.999 percent (5-log) removal/inactivation of giardia cysts, while the minimum required 3-log removal/inactivation is sufficient for sources with no significant microbiological contamination from human activities, a 4-log removal/inactivation of cysts should be provided for source waters whose level of microbiological contamination is between these two extremes.

There is very little human or agricultural activity near the Groundhog River upstream of Fauquier. However, to be conservative, the disinfection requirement will be calculated for a 4-log removal/inactivation of giardia cysts. Well operated conventional treatment plants which have been optimized for turbidity removal can be expected to achieve at least a 2.5-log removal of giardia cysts. The required CT will be based on 1.5-log inactivation of giardia cysts (4.0-2.5-log).

Examples of CT calculations for winter and summer conditions are presented in Appendix F. The contact time (T) in the clearwell is estimated by using the maximum daily flow for the winter and the summer under the worst condition, where the reservoir is half full. This should reflect the situation at the water treatment plant where the package treatment units are

producing the maximum daily flow, and the high lift pumps are pumping at peak hourly rate to the distribution system.

Based on the "Guidance Manual for Compliance With the Filtration and Disinfection Requirements for Public Water Systems Using Surface Water Source" (U.S. EPA, 1990), the baffle condition in the clearwell expressed as T_{10}/T factor can be evaluated to estimate the effective contact time in the clearwell. This factor represents the ratio between T_{10}, which is the time it takes 10 percent of a dye or tracer to pass through the basin outlet after it is injected into the basin influent flow, and the theoretical detention time for plug flow in pipelines and flow in a completely mix chamber.

When tracer studies are not available, a description of the clearwell and baffling condition can be used to estimate the T_{10}/T factor. The clearwell for Fauquier treatment plant includes two separate cells, each cell dimensions are approximately 11.6 m long and 7.6 m wide. The cells have unbaffled inlets and outlets, and no intra-basin baffles. This clearwell is qualified as a poor baffling condition. Therefore, a maximum estimate for the T_{10}/T factor is 0.3. The results of the evaluation of residual chlorine concentration required for inactivation of giardia cysts under various conditions (Appendix F.1 and F.2) are summarized in Table 4.3.

TABLE 4.3 Calculation of minimum residual chlorine concentration necessary for inactivation of giardia cysts

CONDITIONS	Free Residual Chlorine Concentration (mg/L) C	Contact Time (minutes) T
Winter condition with the clearwell 1/2 full, and the plant operated 19 h/d	0.28	351
Summer condition with the clearwell 1/2 full, and the plant operated 19 h/d	0.08	307

The results presented in Table 4.3 show that a higher chlorine residual is required during the winter since lower water temperature reduces the rate of inactivation. Information collected from the water plant shows that the total chlorine residual is normally maintained at 0.5 mg/L. Assuming that most of the total chlorine is present as a free chlorine residual, this would be sufficient to provide adequate inactivation of giardia cysts. Recently the operating staff have been measuring both free and total chlorine, and will be maintaining a free residual of 0.5 mg/L. The plant has leeway to lower its free chlorine dosage through the summer, providing that a minimum free chlorine resisdual of 0.2 to 0.3 mg/L can be maintained at the end of the distribution system

5.0 OFF-SITE BENCH SCALE EVALUATIONS

5.1 INTRODUCTION

The off-site bench scale study was conducted in July 1996 by the MOEE Science & Technology Branch, Water & Wastewater Optimization Section. The primary objective of this study was to determine what combination(s) of treatment chemicals could be tried at plant-scale to improve the performance of the Fauquier water plant in terms of colour and turbidity removal.

The treatability study was conducted using a conventional mode of treatment consisting of coagulation, flocculation, sedimentation and filtration, as per the plant's mode of treatment.

5.2 RAW WATER QUALITY

Bulk raw water samples collected in July 1996 were used for the study. Raw water analytical results are summarized in Table 5.1. The raw water source is the Groundhog River. Raw water quality is generally good. Turbidities are relatively low, but the colour is high and varies depending on the season and rainfall within the watershed. Alkalinity is high enough for alum addition and adjustment is therefore not required.

5.3 JAR TEST CONDITIONS

All jar testing was performed at approximately 20°C. Jar testing conditions are summarized in Table 5.2. All jars were subjected to the same general conditions.

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Table 5.1

Novamann Analytical Results

Parameter	Raw Water
THM Formation Potential (ug/L)	794
Turbidity (NTU) *	15.3
Colour (TCU)	62.6
Total Organic Carbon	17.9
Total Alkalinity (as CaCO3)	52.0
Total Hardness (as CaCO3)	58.5
pH *	7.93
Conductivity (umho/cm)	98.7
Aluminum	0.740
Iron	0.919
Manganese	0.093
Copper	0.294
Lead	0.011
Zinc	0.024
Sodium	2.44
Potassium	<1
Calcium	17.3
Magnesium	3.73
Sulphate	3.8
Chloride	1.3
Fluoride	<0.1
Nitrate-N	0.2
Nitrite-N	<0.1
Ammonium-N	<0.05

All units are mg/L unless otherwise noted.

* Results for these parameters are unreliable unless measured at time of sampling.

Table 5.2 Date: July 10, 1996

TREATABILITY STUDY OBJECTIVE			
Optimize treatment for colour and turbidity removal.			
Raw Water Source:	Groundhog River		

JAR TEST CONDITIONS			RAW WATER QUALITY	
Treatment Mode:	Conventional		**Temperature**	22 deg.C
Flash Mix:	Time	1 minute	**Alkalinity**	60 mg/L
	Speed	100+ rpm	**pH**	6.84
Flocculation:	Time	20 minutes	**Turbidity**	8.3 NTU
	Speed	20 rpm	**Colour**	150 CU
Sedimentation:	Time	30 minutes		(apparent)
Filter Media:	Whatman 541 paper			

CHLORINE DEMAND				TTHM FORMATION POTENTIAL			
Jar #	Cl2 (mg/L)	Free (mg/L)	Total (mg/L)	Jar #	Cl2 (mg/L)	THM (ug/L)	time/temp
	1				1		
	2				2		
	3				3		
	4				4		
	5				5		
	6				6		

Seven-day Formation Potential Result: **794 ug/L**

ADDITIONAL COMMENTS
Plant consists of two Neptune Waterboy plants in parallel (plants #1 & 2).
Liquid alum added at 80 mg/L with 8170 polymer.
Chlorine added to clearwell inlet on plant 2 side only.
Soda ash added to clearwell inlet on plant 2 side for post-pH adjustment.
Raw samples submitted to Novamann for Aquapak, TOC, and THM fm potential.

5.4 PRELIMINARY JAR TESTS

Several primary coagulants (aluminum sulphate, polyaluminum chloride and ferric sulphate) and coagulant aids were examined. Preliminary jar test results are summarized in Appendix B (Tables B.1 to B.12).

5.4.1 Aluminum Sulphate

Aluminum sulphate (alum) was applied at dosages that ranged from 60 to 110 mg/L along with the plant's coagulant aid, 8170 polymer, at 0.1 mg/L. Based on floc quality, supernatant and filtrate colour and turbidity, and aluminum residual, the optimum alum dosage appeared to be 90 mg/L.

In an attempt to improve treated water and floc quality, eleven polymers (including 8170) were tried in conjunction with the optimum alum dosage of 90 mg/L. Similar analytical results were obtained with several polymers but Percol LT20 was the best based on superior floc quality and settling. Colour and turbidity reduction was acceptable and the aluminum residual was less than the ODWO operational guideline.

5.4.2 Polyaluminum Chloride (PACL)

PACL (Sternpac) was applied at dosages that ranged from 40 to 75 mg/L along with the plant's coagulant aid, 8170 polymer, at 0.1 mg/L. PACL plus 8170 produced a floc that was similar to alum plus 8170, however the turbidities and aluminum residuals were lower. Colour removal was similar to alum. Based on floc quality, colour, turbidity and aluminum residuals the optimum PACL dosage was 70 mg/L.

Seven polymers (including 8170) were tried in conjunction with the optimum PACL dosage of 70 mg/L. These seven polymers were previously tried with alum, enabling comparisons to be made. In general, floc quality was slightly worse than that obtained with alum. Turbidities in supernatant and filtrate, and residual aluminum, were significantly lower than in the alum treatment. Colour removal in supernatant was also superior to alum, and colour in filtrate was similar. Based on water and floc quality, 8170 was judged to be the best polymer.

5.4.3 Ferric Sulphate (HFS)

This primary coagulant (Ferriclear) was tried as an alternative to alum. Hydroxylated ferric sulphate (HFS) was applied at dosages that ranged from 45 to 100 mg/L without a polymer. Based on supernatant and filtrate turbidities, the optimum dosage was found to be 90 mg/L.

Six polymers were tried in conjunction with the optimum Ferriclear dosage of 90 mg/L. These six polymers were previously tried with alum and PACL, enabling comparisons to be made. Turbidities were lower than alum but higher than PACL. Colour removal was better than alum and similar to PACL. Floc quality in the best jars was not as good as the floc produced with alum and PACL.

5.4.4 Discussion of Results

A comparison between alum and Ferriclear (with polymers added) shows that alum gave better floc quality. Supernatant and filtrate turbidity and colour is significantly better with Ferriclear, although the alum colour and turbidity is perfectly acceptable. Floc quality is important when trying to settle a colour floc, and the optimum dosages for alum and Ferriclear were the same. Therefore it was decided that Ferriclear would not be included in the final runs.

A comparison between alum and PACL (with polymers added) shows that alum gives slightly better floc quality, with the exception of alum plus LT20, which produced floc that was much better than any combination of chemicals. PACL was significantly better at removing colour and turbidity and produced much lower aluminum residuals.

There was not enough sample remaining to optimize polymer dosages. Past experience has shown that improvements in floc strength and settleability can be realized by doing so.

5.5 FINAL RUNS

During final runs the chemical treatment included post-chlorination. Based on the preliminary jar test results, three chemical treatments were selected for analysis during final runs. Dosages and observations are summarized in Table 5.3. Analytical results are included in Table 5.4.

5.5.1 Aluminum Sulphate

Four 2-L jars were treated with alum at a dosage of 90 mg/L and Percol LT20 polymer at 0.1 mg/L. After settling, 1 L of supernatant was taken from each of the 4 jars and combined into one 4-L sample which then was filtered. The 4-L sample was then split: one sample was chlorinated to a free residual of 1 mg/L, while the other was pH adjusted to a pH between 7.5 and 8.0 with soda ash as per the plant and was then chlorinated to a free residual of 1 mg/L. The reason for the soda ash versus unadjusted sample was to see if moving the soda ash feed point in the clearwell from the entrance to the exit of the clearwell affects THM levels.

Table 5.3

Objective: FINAL RUNS - PACL vs. Alum (with & without post soda ash)

Date: July 30, 1996 **Sample Volume: 2 L** **Run #: FINAL**

Chemical Dosages (mg/L)

Jar	Alum	LT20 (N)		PACL	8170 (C)				
1	90	0.1							
2	90	0.1							
3	90	0.1							
4	90	0.1							
5				70	0.1				
6				70	0.1				

Observations

1	
2	
3	
4	
5	
6	
	Floc was as expected - no surprises - alum + LT20 gave best floc.

Chemical Analysis Data

	Supernatant				Filtrate				
Jar	**Turbidity**	**Colour**	**pH**	**Alkalinity**	**Turbidity**	**Colour**	**pH**	**Alkalinity**	**Al. Res.**
1			-	-	-	-	-	-	-
2	0.48	8	-	-	-	-	-	-	-
3			-	-	-	-	-	-	-
4			-	-	-	-	-	-	-
5	0.10	5	-	-	-	-	-	-	-
6			-	-	-	-	-	-	-
	NTU	TCU	pH units	mg/L	NTU	TCU	pH units	mg/L	mg/L

Comments

See page 3&4 of MOEE report for details.

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Table 5.4

Novamann Analytical Results for Final Runs			
Parameter	Alum (+Soda Ash)	Alum	PACL
Total THMs (ug/L)	41 *	46	66
Turbidity (NTU) **	1.2	0.4	1.1
Colour (TCU)	2	1	<1
Total Organic Carbon	3.1	2.6	2.6
Free Chlorine Residual ***	1	1	1
Total Alkalinity (as CaCO3)	40.0	20.0	32.0
Total Hardness (as CaCO3)	59.8	62.2	61.4
pH **	7.96	7.71	7.76
Conductivity (umho/cm)	178	134	135
Aluminum	0.128	0.144	0.074
Iron	0.048	0.035	0.012
Manganese	0.020	0.021	0.017
Copper	0.040	0.044	0.025
Lead	<0.002	<0.002	<0.002
Zinc	0.017	0.014	0.024
Sodium	16.7	3.67	3.53
Potassium	<1	<1	<1
Calcium	17.7	18.4	18.1
Magnesium	3.81	3.96	3.95
Sulphate	45.1	39.9	11.3
Chloride	4.9	4.2	20.1
Fluoride	0.6	0.6	<0.1
Nitrate-N	0.3	0.3	0.3
Nitrite-N	<0.1	<0.1	<0.1
Ammonium-N	<0.05	<0.05	<0.05

All units are mg/L unless otherwise noted.

* When free residual was held to 0.5 mg/L, THM level was 41 ug/L.

** Results for these parameters are unreliable unless measured at time of sampling.

*** Measured in MOEE lab 10 minutes after chlorine addition. There was a measureable residual after 24 hours SDS contact.

The two splits were sampled following treatment for general chemistry and total organic carbon. In addition, samples for THM analysis were collected in 250 mL glass bottles with no head space, held for 24 hours at 20 °C in darkness to simulate the distribution system, and then quenched with sodium thiosulfate. One special THM sample was collected for the alum and soda ash treatment at a free chlorine residual of 0.5 mg/L (instead of 1 mg/L). All of these samples were submitted to Novamann Labs.

5.5.2 <u>**Polyaluminum Chloride (PACL)**</u>

Two 2-L jars were treated with PACL at a dosage of 70 mg/L and 8170 polymer at 0.1 mg/L. After settling, 1 L of supernatant was taken from each of the 2 jars and combined into one 2-L sample which then was filtered. The 2-L sample was then chlorinated to a free residual of 1 mg/L.

Sampling was done following treatment for general chemistry and total organic carbon. In addition, a sample for THM analysis was collected in a 250 mL glass bottle with no head space, held for 24 hours at 20 °C in darkness to simulate the distribution system, and then quenched with sodium thiosulfate. All of these samples were submitted to Novamann Labs.

5.5.3 <u>**Discussion of Results**</u>

Real-time measurement of supernatant turbidities and colour in the MOEE lab showed that PACL was better at removing turbidity and colour, which was consistent with the preliminary runs. The performance of the alum though was quite acceptable. Floc quality was consistent with earlier runs; the alum plus LT20 was better. Novamann results showed that aluminum residuals were above the ODWO of 100 µg/L for both alum treatments, but below the ODWO for PACL. For the alum and PACL treatments, the residuals were significantly higher than those in the preliminary runs. It is not possible to say if this is real or due to differences between Novamann ICP (Inductively Coupled Plasma Atomic Emission Spectroscopy) method and the DR2000 spectrophotometer with Hach ECR (Erichrome Cyanine R) reagents used in the MOEE lab.

There were problems with measurement of pH in the MOEE lab, which affected the dosing of soda ash to achieve a higher pH. The raw water pH from Novamann was 7.93. The pH results from the Novamann lab show a pH of 7.96 in water with alum and soda ash added versus 7.71 in water with alum only. This is not a big difference, which may explain why the corresponding THM levels (41 and 46 μg/L) were close. It therefore was not possible to determine if pH had any effect on THM formation (the literature says it does).

For the alum plus soda ash treatment, water was chlorinated to free residuals of 0.5 and 1.0 mg/L and the corresponding THM level was 41 μg/L for both chlorine dosages. After 24 hours free chlorine was still present in both samples, at least at levels above 0.5 mg/L.

For the PACL treatment, the THM level was 66 μg/L. This is surprising given that the TOC level was as low as the alum treatments.

5.6 CONCLUSIONS

All three primary coagulants examined during this study are capable of producing a treated drinking water in compliance with the ODWO.

Ferriclear produced a floc that was poor in comparison with alum and PACL, and at 90 mg/L did not offer any advantage over alum in terms of cost. It was therefore excluded from the final runs.

The optimum alum dosage for the raw water sample for this treatability study was 90 mg/L. Together with Percol LT20 polymer at 0.1 mg/L, the turbidity and colour obtained were quite acceptable. But the big difference was the production of a strong floc with excellent settleability. This is very important to the performance of a plant dealing with hard-to-settle colour floc. The polymer dosages were not optimized during this study; past experience indicates that floc quality can be improved even further by doing so.

The optimum PACL treatment was at 70 mg/L together with 8170 polymer at 0.1 mg/L. The polymer dosage was not optimized during this study. PACL produced both good quality floc and finished water. Further studies should be carried and consist of conducting a plant scale trial with alum and Percol LT20 polymer.

6.0 0N-SITE BENCH SCALE EVALUATIONS

The Fauquier Water Treatment Plant was visited during September 23 to 26, 1996 by Matt Uza of the Science and Technology Branch of MOEE. The material presented in this section is a summary of field notes. The intent of the visit was:

1. to switch to Percol LT20 polymer to hopefully improve plant performance,
2. sample raw, treated, and distribution water for THMs and related parameters,
3. train the operator (Linda Beaudet) in process monitoring, jar testing, and plant control,
4. alter operational procedures and/or administrative policies if needed.

6.1 ON-SITE SAMPLING

THM and other samples were collected in the afternoon on September 23 and in the morning on September 24, 25 and 26 for raw, treated, and distribution system.

6.2 DAILY PROCESS MONITORING

The operator had not been measuring aluminum because she was told that the aluminum method was not accurate. A supply of HACH ECR (Eriochrome Cyanine R) reagents were brought along to show the operator how to conduct the ECR test on her DR2000 spectrophotometer.

Only total chlorine residual was measured prior to this visit. HACH reagents for free chlorine were brought to the plant and the procedure was taught to the operator. A supply of reagents were left at the plant, as well as a HACH catalog.

6.3 PLANT OBSERVATIONS

6.3.1 Tuesday, September 24

It was noticed that severe floc carryover occurred overnight, especially at Plant No. 2. It appears that the settling tank had simply become full of sludge, and the floc took a path of least resistance over the top of the tube settlers, past the overflow barrier, and onto the filters. The immediate solution was to waste sludge more often; perhaps the settling of floc could be improved by LT20.

It was also observed that there was a major buildup of sludge in both halves of the clearwell. Also, in the Plant No. 2 side, an accumulation of anthracite was visible directly under the filter effluent pipe into the clearwell - the underdrains are likely deteriorating. Some sand is also probably present along with the anthracite, but it would not show up easily against the floor of the clearwell.

The presence of mudballs in the filters was noticed. This confirms the suspected poor backwashing.

6.3.2 Wednesday, September 25

It was noticed on Wednesday that the operator was still only feeding chlorine into side 2 of the clearwell. Previous instructions were misunderstood, and the operator assured that chlorine feed into side 1 and side 2 of the clearwell would begin in October. The results of THM testing before and after this change are presented in Table 6.1. It appears that this process modification did not have any real impact on the formation of THM.

In the afternoon it was also noticed that the tube settlers in Plant No. 2 were right at the water surface, whereas in Plant No. 1 the tubes were placed 8 to 10 inches below the water surface. This definitely contributes to the floc carryover in Plant No. 1 - when the tank fills with sludge

the floc travels over the top of the tubes and carries over. It was discovered afterward that the tube settlers in the bottom of Plant No. 1 were crushed due to the weight of sludge accumulation on the bottom plates. New tube settlers were ordered and should be installed early winter, 1997.

6.3.3 **Thursday, September 26**

The Plant No. 2 settling tank was drained all the way to the bottom to check if a part of it might be obstructed causing zones of high upflow velocity. It appears that there is adequate clearance along the whole length of inflow baffle.

6.3.4 **Calculation of Daily Chemical Dosages**

The daily chemical dosages are calculated at the plant by measuring the amount of chemicals used and the daily flow volume. It was suspected that a mistake was made in the evaluation of alum dosage since the typical alum dosage calculated at the plant was around 40 mg/L, and jar tests performed at the MOEE lab showed that the optimum dosage was approximately 90 mg/L. Jar tests showed that floc formation at 40 mg/L was very poor. Also, sulphate levels in treated water pointed to an alum dosage of 80 to 90 mg/L.

It appears that the daily amount of liquid alum used is accurately measured, and the concentration of the alum solution is known. The calculation of raw water flow was the source of the error. It was discovered that when the operator was converting weir head to flow rate, the wrong conversion factors were being used.

TABLE 6.1 FAUQUIER WATER TREATMENT PLANT
TOC AND TTHM ANALYSIS IN OCTOBER 1996
WATER SAMPLES ANALYZED BY NOVAMANN

PARAMETERS	Chlorinating in one Cell of the Clearwell (21/10/96)	Chlorinating in one Cell of the Clearwell (22/10/96)	Chlorinating in two Cells of the Clearwell (24/10/96)	Chlorinating in two Cells of the Clearwell (25/10/96)
TOC - Raw Water (mg/L)	9.7	9.8	10.7	9.5
TOC - Treated Water (mg/L)	3.5	3.7	4.1	4.3
TTHM - Quenched Treated Water (ug/L)	41	34	50	37
TTHM - Quenched Distribution System (ug/L)	64	64	78	58

The operator has now changed the raw water flow volume calculation on her log sheet, and the correct dosages of alum and polymer are now calculated. It was also noticed that the calculation for chlorine and soda ash dosages was based on raw flow volumes. This is the proper way to calculate the dosage for chlorine, but the soda ash dosage should be based on the treated water flow volumes since the soda ash injection point was relocated to the high lift pumps in the fall, 1996.

There is still a problem with flow measurement at the plant since the records show that the treated flow is larger than the raw water flow. The raw flow measurement with weirs is unreliable, and the treated turbine meter may be in error as well.

6.4 JAR TESTING

Two jar tests were conducted on Tuesday, September 24. A 1% W/V alum stock solution was prepared. A pre-mixed polymer solution was brought along since it takes too long to make it up on site. The desired dosage was evaluated by using an equation to determine the amount of stock solution to add.

One test was run to determine the optimum alum dosage, while the other compared 8170 with LT20. The test did not show any difference between these two polymers, unlike the tests in the Toronto lab which showed that LT20 produced a faster settling floc than 8170. However, it was decided to run the LT20 at full scale on Wednesday anyway. The procedures used for on-site jar testing is presented in Appendix C (Table C.1). The jar test results are presented in Tables C.2 and C.3 (Appendix C).

6.5 CHANGING POLYMER TO LT20

The LT20 feed rate was adjusted to attain a dose of 0.3 mg/L. The previous feed rate of 68 mL/min for the 8170 resulted in an LT20 dosage of 0.45 mg/L, which may be too high and may contribute to filter backwashing problems. Calculations were done to obtain the required LT20 feed rate, and pump stroke was adjusted until the correct feed rate (measured with a cylinder and stopwatch) was achieved. The demonstration of calculations used to adjust the required feed rate is presented in Appendix D.

The results from plant monitoring performed to compare the performance of 8170 polymer versus LT20 are summarized in Table 6.2. The results show that for a raw water turbidity ranging from 2.29 NTU to 3.69 NTU from September 23, to September 26, the treated water turbidity when using 8170 range from 0.7 to 0.9 NTU, and the treated water turbidity with LT20 is better with 0.62 NTU. The results show that for a raw water apparent colour ranging from 68 to 81 ACU (Apparent Colour Unit), the treated water colour when using 8170 is 4 ACU, and the treated water colour when using LT20 is 3 ACU. The best improvement in the treated water quality was observed for the residual aluminum, where the results show a residual aluminum ranging from 129 to 151 μg/L with 8170 poly, and 79 to 88 μg/L when using LT20.

6.6 FOLLOWING WEEKS

During telephone conversation with the operator during the week of September 30 to October 4, the operator indicated that the floc carryover problem has disappeared after switching to the LT20. The following week (October 7 to 11), the operator switched back to the 8170 and the carryover problem re-appeared. It seems obvious that the LT20 has significantly improved floc settling and associated carryover onto the filters. The operator is reserving some LT20 in order to conduct a trial in December after ice covers the river to see how the LT20 performs compared to 8170 in cold water.

MOEE/STB On-Site Process Monitoring Results - Fauquier WTP

Date: September 23-26, 1996

Table 6.2

Location	Date*	Temp. (deg.C)	Turbidity (NTU)	App. Colour (TCU)	TOC (Nova) (mg/L)	pH (Nova)	Alkalinity (mg/L)	Al Resid. (mg/L)	Free Cl2 (mg/L)	Total Cl2 (mg/L)	THM Quenched (Nova) (ug/L)
Raw	23/09/96	13	3.69	68	8.1	-	62	-	-	-	-
	24/09/96	13	2.70	78	9.2	-	70	-	-	-	-
	25/09/96	13	2.29	81	8.5	-	68	-	-	-	-
	26/09/96	12	3.14	81	8.7	-	-	-	-	-	-
Treated	23/09/96	-	0.90	-	2.6	7.51	40	0.151	0.48	0.52	41
	24/09/96	-	0.70	4	2.4	7.33	50	0.129	0.81	0.93	38
	25/09/96	-	0.62	3	2.3	7.27	-	0.079	0.45	0.64	38
	26/09/96	-	0.62	3	2.2	7.20	-	0.088	0.34	0.83	38
Distribution**	23/09/96	-	-	-	2.8	7.52	-	-	0.27	0.43	62
	24/09/96	-	-	-	2.4	7.28	-	-	0.97	1.20	66
	25/09/96	-	0.72	-	2.4	7.23	-	-	0.36	0.56	64
	26/09/96	-	-	-	2.1	7.23	-	-	0.44	0.65	56

NOTES: *: The plant used 8170 poly on September 23 and 24, 1996, and it used LT20 on September 25 and 26, 1996.

**: 30 Gauthier Street

7.0 CONCLUSIONS

The results for water samples taken in July and August 1996 showed levels of THM ranging from 97 to 140 µg/L in the distribution system. The THM results obtained from on-site testing performed in September, 1996 at Fauquier Water Treatment Plant after the relocation of soda ash injection to the high lift pump, show THMs ranging from 50 µg/L to 66 µg/L in the distribution system, indicating a significant reduction in THM levels. It will be important to monitor the level of THM during summer, after the implementation of the proposed recommendations presented in Chapter 8.0, to confirm that the Fauquier plant is in compliance with the 100 µg/L ODWO for THMs in the treated water as a running average of four quarterly samples.

Information collected from the water plant shows that the total chlorine residual is normally maintained at 0.5 mg/L. Assuming that most of the total chlorine is present as a free chlorine residual, this is sufficient to provide adequate inactivation of giardia cysts and viruses. Operating staff should monitor 'free' chlorine residual to ensure 0.5 mg/L is achieved during the winter. The plant has leeway to lower its free chlorine dosage during the summer providing that a minimum free chlorine residual of 0.2 to 0.3 mg/L range can be maintained at the end of the distribution system.

The turbidity of the treated water ranges from 0.4 to 0.9 NTU with an average of 0.7 NTU. This is below the ODWO for turbidity of 1 NTU, however, it is high considering that disease outbreaks caused by giardia and cryptosporidium have been reported with increased frequency over the last decade in Canada and the US. These protozoan parasites (especially cryptosporidium) are more difficult to kill with disinfectants, and therefore their removal by physical processes is vital. As a result, Health Canada is now examining the need for stricter standards for particle removal in water plants.

Current US research and experience now indicates that a turbidity of 0.1 NTU in filter effluent is needed to provide protection from cryptosporidium. Improvement should be made at the plant to reduce floc carried over from the clarifier to the filter to help in achieving a turbidity of 0.1 NTU. It is understood that new plate settlers were ordered for replacement in the clarifier of the two package treatment units. This would help reducing floc carried over. Continuous monitoring of filter effluent turbidity would provide the operator with a more direct measure of plant performance. Improvement of the backwash procedure and sludge removal in the clarifier for Plant No. 1 would also help to reduce floc carried over and filter effluent turbidity.

There is not a lot of historical data available regarding the level of aluminum residual found in the treated water. On-site testing performed in September 1996, when using the regular polymer used at the plant, 8170, showed an average aluminum residual of 140 µg/L which is higher than the ODWO of 100 µg/L. It appears that using LT20 improved the level of aluminum residual with an average value observed in September 1996 of 84 µg/L.

Very high levels of aluminum residual in the treated water were recently observed by the plant operator. Aluminum residual as high as 221 µg/L was found in the treated water in February 14, 1997. It appears that the raw water condition is responsible for reducing the performance of the coagulation process with alum. The raw water conditions found in February 14 were a pH of 5.6, and alkalinity of 22 mg/L. Such a low pH is surprising, however, it is clear that the pH and the alkalinity of the raw water are too low for the alum reaction, and pre-alkalinity adjustment is required at certain times of the year.

8.0 RECOMMENDATIONS

The following is a summary of recommendations for plant and operational modifications required to ensure that Fauquier Water Treatment Plant will comply with the ODWO for THM and aluminum residual, will maintain adequate disinfection and will be more cabable of achieving for a turbidity in the filter effluent of 0.1 NTU:

1. Shift alum addition to a common point downstream of new flow meter but before the split to Plant No 1 and No 2, install in-line static mixer immediately downstream from alum addition;
2. Install a mag. meter for raw water flow measurement;
3. Inspect filter underdrains in Plant No. 2 to determine the extent of the damage causing media to enter clearwell;
4. Provide continuous monitoring of settled water pH and alarm to alert operator of process upsets;
5. Sludge wasting is not adequate - increased operator attention of approximately 1 hour per day is needed. Automation of sludge removal may be consider as an option. Adequate draw down of the clarifier and sufficient flushing of the tubes is essential;
6. Install flow through turbidimeters and a recorder for Plants No 1 and 2 treated water;
7. Install a continuous soda ash feed to the raw water to offer the flexibility to do pH/alkalinity adjustment when needed;
8. Lower the chlorine dosage during the summer to a level ensuring that a minimum free chlorine residual between 0.2 to 0.3 mg/L can be maintained at the end of the distribution system. This will help to keep down THM levels;
9. Operate the plant to maintain a free chlorine residual of 0.5 mg/L in the winter;
10. Routine flushing of the watermains in the distribution sysytem to be able to apply and maintain a low chlorine dosage during the summer;
11. Install an improved backwash system for the filters by adding a manual air scour system;

12. Free AND total chlorine residual must be measured daily;

13. The operator should be given training needed to progress to the required level of certification.

The following is a summary of operation improvements that have already been implemented:

- Automation of Plant No. 2 to reduce the amount of treated water overflowed to the river;
- Relocation of soda ash injection point to the high lift pumps;
- Chlorine disinfection added to each cell of the clearwell;
- Ordered replacement settler plate modules for each package treatment unit.

Arrangement will be made with Novamann laboratories to provide additional water testing of the raw water (turbidity, colour, pH, alkalinity and TOC), the treated water (turbidity, colour, pH, alkalinity, TOC, THM and aluminum), and the distribution system (colour, TOC and THM) starting in spring 1997.

9.0 COST ESTIMATE FOR IMPLEMENTATION

Table 9.1 is a summary of capital expenditure involved for the implementation of the recommended upgrades. The figures presented are preliminary estimates prepared to give an idea of the price range involved.

TABLE 9.1 Capital Estimates

PROPOSED MODIFICATIONS	COST ($)
Automation of sludge removal (Option)	$6,000
Mag. meter and chart recorder for raw water flow measurement	$8,000
Alum addition to a common point downstream of new flow meter but before the split to Plants No. 1 and 2 and install in-line mixer	$5,000
Manual air scour system for filter backwash	$20,000
Continuous monitoring of settled water pH	$7,000
Continuous monitoring of treated water turbidity	$9,000
Soda ash feed to the raw water	$5,000
TOTAL:	**$60,000**

GLOSSARY AND LIST OF ABBREVIATIONS

Alum	: aluminum sulphate
CT	: Value required to achieve adequate inactivation and/or removal of cysts and viruses. T is the time (in minutes) it takes the water during peak hourly flow, to move between the point of disinfectant and a point where C, the residual disinfectant concentration (mg/L), is measured prior to the first customer.
d	: day
°C	: degree Celsius
DWSP	: Drinking Water Surveillance Program
ECR reagent	: Eriochrome Cyanine R
FID	: Flame Ionization Detector
ft	: foot
G	: flocculation energy gradient
Gt	: flocculation energy
GC/MS	: Gas Chromatograph / Mass Spectrometry
GAC	: Granular Activated Carbon
g	: gram
h	: hour
HFS	: hydroxylated ferric sulphate (Ferriclear)
ICP	: Inductively Coupled Plasma Atomic Emission Spectoscopy
IG	: imperial gallon
kW	: kilowatt
L	: litre
L/cap.d	: litres per capita per day
L/s	: litres per second
m	: metre
m^2	: square metres
m^3	: cubic metres

m^3/d	: cubic metres per day
m/h	: metres per hour (equivalent $m^3/m^2.h$ - filtration rate)
μg/L	: micrograms per litre
mg/L	: milligrams per litre
mm	: millimetre
mL/min	: millilitres per minute
min	: minute
NTU	: Nephelometric Turbidity Unit
OCWA	: Ontario Clean Water Agency
ODWO	: Ontario Drinking Water Objective
%	: percent
PACL	: polyaluminum chloride
PVC	: polyvinyl chloride
lb	: pound
rpm	: revolution per minute
SOR	: Surface Overflow Rate
SWTR	: Surface Water Treatment Rule
T_{10}/T	: This factor describes the baffling condition in the clearwell, and represents the ratio between T_{10}, which is the time it takes 10 percent of a dye or tracer to be detected at the basin outlet after it is injected into the basin influent flow, and the theoretical detention time for plug flow in pipelines and flow in a completely mixed chamber.
TOC	: Total Organic Carbon
THMs	: Trihalomethanes
TCU	: True Colour Unit
W/V	: weight/volume

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American Water Works Association Research Foundation - Optimizing Chloramine Treatment, 1993.

Environmental Science and Engineering Magazine. Drinking water Update - The Facts About Human Health and Aluminum in Drinking Water, January, 1997.

U.S. Environmental Protection Agency, Science and Technology Branch Criteria and Standards Division of Drinking Water. Guidance Manual for Compliance With the Filtration and Disinfection Requirements for Public Water Systems Using Surface Water Sources, October , 1990.

Ontario Ministry of the Environment, Environmental Approvals and Land Use Planning Branch. Guidelines for the Design of Water Treatment Works, April 1982.

APPENDICES

Plant Survey

Appendix A

PLANT Shipping Address: Tel: (705) 339-5121	**Fauquier Water Treatment Plant** P.O. Box 40, Fauquier Ont., P0L 1G0 2 Gravel Street Fax: (705) 339-2421
PREPARED BY: **R.A. LeCraw, P.Eng.**	**DATE: Plant Visit June 17/96**

STAFF:
Superintendent: Linda Beaudet
No. of Operators: 1

Hours in Attendance: 4h/d   Certified Y/N: Y

PLANT CAPACITY: Typical Average Daily Flow: 200 m3/d (1995) Maximum Daily Flow: 375 m3/d (1995) Population Served: 500 +/-	**OPERATING AUTHORITY:** Township of Fauquier-Strickland **YEAR OF CONSTRUCTION:** 1971

SOURCE OF RAW WATER: Groundhog River

RAW WATER CHARACTERISTICS:
- Colour: 30 to 80 TCU (July -Sept 96)
- Turbidity: 2 to 6.7 NTU
- pH: 7.8 to 8.1
- Alkalinity: 47 to 77 mg/L
- Algae Counts: N/A

CHEMICALS:

- Coagulant: Type: Alum,
  Dosage: 50-100 mg/L (Summer), 40-50**mg/L (Winter) ** Possible calc. error
  Injection Point: To each leg of feed pipes. No mixing other than pipe turbulence

- Coagulant Aid: Type: 8170
  Dosage: 0.1-0.17** mg/L ** Possible calc. error
  Injection Point: Directly into floc basin of Water Boy

- Alkalinity/pH Adjustment: Chemical Used: Soda Ash
  Dosage: 20-80mg/L (Summer), 15-40 mg/L (Winter)
  Injection Point: Post only in clearwell

- Disinfection: Type: Sodium Hypochlorite
  Dosage: mg/L (Summer), mg/L (Winter)
  Injection Point: Post only, after filters

ANALYSIS PERFORMED ON-SITE: Colour Alkalinity Turbidity pH	**LAB EQUIPMENT AVAILABLE:** Hach DR 2000

PROCESS CONFIGURATION:

CHEMICALS METERING:

	TYPE	CAPACITY	CONTROL	CONDITION
• Coagulant:	Alum	N/A	Auto on/off Manual speed control only	Good
• Coagulant Aid:	8170		Auto on/off Manual speed control only	Good
• Alkalinity /pH Adjustment:	Soda Ash		Auto on/off Manual speed control only	Good
• Disinfection:	Sodium Hypochlorite		Auto on/off Manual speed control only	Good
• Other:				

PROCESS CONFIGURATION (Continued):

INTAKE:	TYPE				CONDITION	NOTES
SCREENING:	TYPE	NO	DIMENSIONS		CONDITION	NOTES
LOW LIFT PUMPS:	TYPE	NO		CAPACITY	CONDITION	NOTES
	Submersible	2		6 kW (8 HP)	There were no issues related to low lift pumping.	
HIGH LIFT PUMPS:	TYPE	NO		CAPACITY	CONDITION	NOTES
	Vertical Turbine	3		2 pumps: 5.6 kW (7.5 HP) 1 pump: 22.4 kW (30 HP)	There were no issues related to high lift pumping.	
MIXING:	TYPE				CONDITION	NOTES
	Inlet baffles and weir provide some mixing					
FLOCCULATION:	TYPE	NO	DIMENSIONS	VOLUME	CONDITION	NOTES
	Mechanical					No speed control.
CLARIFICATION:	TYPE	NO			CONDITION	NOTES
	7° inclined tubes				Plant # 1 tubes not well sealed to inlet plate. Considerable bypass of floc.	
FILTERS:	TYPE	NO	DIMENSIONS	CAPACITY	CONDITION	NOTES
	Dual media sand anthracite.				Staff ordered GAC in stead of anthracite and have been topping up the filters with this.	
CLEARWELL/: ON-SITE RESERVOIR		NO	DIMENSIONS	VOLUME	BAFFLED: Y/N	NOTES
		2 cells	11.6m X 16.8m X 4.45m (38 ft X 55 ft X 14.6 ft)	682 m^3 (150,000 IG)	No	

PLANT CONTROL:

- Flow (Manual Set/Auto): Manually set by low lift pump selection & manual throttling of raw water flow.
- Level: On/Off control on low lift pumps from clearwell level.

PROCESS MONITORING:

	INSTRUMENT	MONITORING FREQUENCY	LOCATION	NOTES
• Turbidity:	Lab monitoring HACH DR 2000	Daily	Raw and filtered	
• pH:	Lab monitoring	Daily	Raw and filtered	
• Total Chlorine Residual:	Lab monitoring HACH DR 2000	Daily	Filtered	
• Temperature:		Daily	Raw	
• Aluminum Residual:	MOEE testing only			
• Colour:	Lab monitoring Hach DR 2000	Daily	Raw and filtered	
• Alkalinity:		Daily	Raw and filtered	